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THE USE OF STUDENT RESPONSE TO IMPROVE TELEVISED INSTRUCTION,
AN OVERVIEW. STUDIES IN TELEVISED INSTRUCTION, REPORT 7.

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A SERIES OF EXPERIMENTS WAS CONDUCTED TO TEST THE
EFFECTIVENESS OF TELEVISED INSTRUCTION. THIS REPORT, THE
SEVENTH, DESCRIBES THE USE OF GENERAL SCIENCE LESSONS FOR
JUNIOR HIGH SCHOOL STUDENTS TELEVISED BY AN EDUCATIONAL
STATION. FOR EACH EXPERIMENT TWO ALTERNATE VERSIONS WERE
PREPARED. ONE VERSION (THE EXPERIMENTAL LESSON) WAS SHOWN,
AND COMPARED WITH THE SECOND VERSION (THE CONTROL LESSON)
SIMULTANEOUSLY TELECAST OVER ANOTHER CHANNEL. DESCRIBED IN
THIS REPORT, IN EACH OF THE THREE TYPES OF STUDIES, STUDENT
PERFORMANCE WAS USED BEFORE, DURING, AND AFTER TELEVISION
LESSONS TO EVALUATE AND IMPROVE TELEVISED INSTRUCTION.
CONCLUSIONS WERE THAT MORE EFFECTIVE USE OF EDUCATIONAL
TELEVISION WILL RESULT FROM SYSTEMATIC ATTENTION TO ITS
METHODS FOR STIMULATING APPROPRIATE STUDENT RESPONSES AND FOR
ALTERING OR REVISING INSTRUCTIONAL PROGRAMS UNTIL STUDENTS
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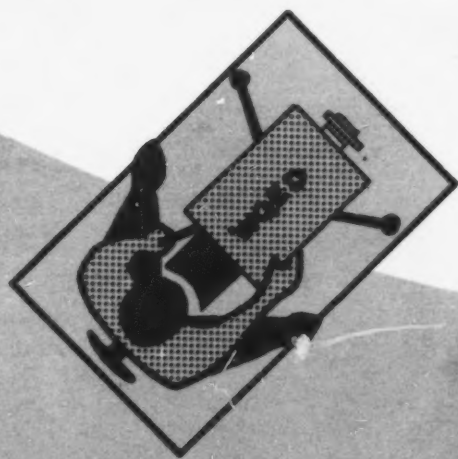
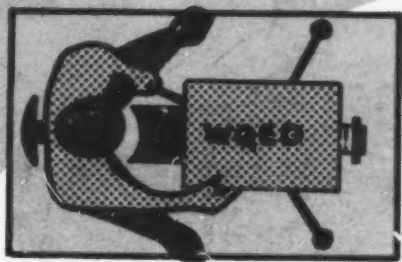
The Metropolitan Pittsburgh
Educational Television Station
and the

American Institute For Research

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

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STUDIES IN TELEVISED INSTRUCTION



THE USE OF STUDENT RESPONSE TO IMPROVE TELEVISED INSTRUCTION: AN OVERVIEW

7

PITTSBURGH, PENNSYLVANIA

STUDIES IN TELEVISED INSTRUCTION

Report Number 7

THE USE OF STUDENT RESPONSE
TO IMPROVE TELEVISED INSTRUCTION,

AN OVERVIEW — *Studies in Televised
Instruction, Report 7.*

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and

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Metropolitan Pittsburgh Educational Television Stations

WQED-WQEX

and

American Institute for Research

Pittsburgh, Pennsylvania

June 1961

STUDIES IN TELEVISED INSTRUCTION

Report No. 1

IMPROVEMENT OF TELEVISED INSTRUCTION
BASED ON STUDENT RESPONSES
TO ACHIEVEMENT TESTS

Report No. 2

AN EXPERIMENTAL COMPARISON OF A CONVENTIONAL TV LESSON
WITH A PROGRAMMED TV LESSON REQUIRING ACTIVE STUDENT RESPONSE

Report No. 3

AN EXPERIMENTAL EVALUATION OF THE CONTRIBUTION
OF SEQUENCING, PRE-TESTING, AND ACTIVE STUDENT RESPONSE
TO THE EFFECTIVENESS OF "PROGRAMMED" TV INSTRUCTION

Report No. 4

AN INVESTIGATION OF THE ROLE OF SELECTED VARIABLES
IN "PROGRAMMED" TV INSTRUCTION: PARTS I AND II

Report No. 5

ISSUES IN
PROGRAMMING INSTRUCTIONAL MATERIALS
FOR TELEVISED PRESENTATION

Report No. 6

AN EVALUATION OF TELEVISION PROCEDURES
DESIGNED TO STIMULATE EXTRACURRICULAR SCIENCE ACTIVITIES

Report No. 7

THE USE OF STUDENT RESPONSE
TO IMPROVE TELEVISED INSTRUCTION:
AN OVERVIEW

A FILM REPORT ON
RESEARCH ON STUDENT RESPONSE
TO TELEVISED INSTRUCTION

TABLE OF CONTENTS

Abstract	I
Introduction	3
Research Approach	6
Pre-Testing TV Lessons	10
"Programming" TV Instruction	16
Stimulating Extracurricular Activities	24
Conclusion	30
Bibliography	32

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George L. Gropper

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ABSTRACT

Students themselves can make a contribution toward improving the quality of instruction they receive on television. The student's own performance before, during, and after TV lessons can help instructors and producers to improve the quality of educational television. Studies were conducted which demonstrated that substantial gains in student knowledge of scientific facts and understanding of scientific concepts could be achieved by systematically paying as much attention to what students did as to what TV instructors did to teach them. Results of these studies also showed that techniques were available to increase student interest in science.

A series of general science lessons for Junior High School students televised by educational television station WQED throughout the school year provided the setting for 12 separate experiments. For each experiment two alternative versions of a lesson were prepared. One version, the experimental lesson, was shown over WQED (Channel 13) and it was compared with the second version, the standard or control lesson, simultaneously telecast over WQEX (Channel 16). With such controlled comparisons, it was possible to evaluate the effectiveness of the various experimental techniques which employed student performance to improve the quality of instruction.

Three types of studies were conducted. First, before a lesson was shown on the air at its regularly scheduled time, a sample student audience saw a preview version of the lesson and were quizzed on it afterward. Results of the quiz showed which points students failed to understand. These results were used as feedback to the TV instructor to enable him to revise and improve his lesson. The lesson was revised accordingly and a comparison was then made of the tryout or preview version and the final or revised version. Students watching either version took identical quizzes afterward. Results showed that the revised version produced significant improvements on various parts of the quiz ranging from six to twenty-six percent. It was concluded that student performance during tryouts and before the actual lesson is shown can provide useful feedback to the instructor enabling him to tailor his presentation to a particular audience. By matching the presentation to student ability to perform, substantially more effective instruction can be produced.

A second technique used during the lesson was shown to be capable of bringing about significant improvements in student learning. It too centered on student

performance, this time during the lesson. Rather than allowing students passively to watch and listen to conventional lectures, special lessons were developed that encouraged them to learn-by-doing. Lessons were prepared in much the same way that lessons are prepared for teaching machines -- that is, they were designed to stimulate students throughout the lesson to answer questions or complete statements begun by the instructor. They were also designed to help students to come up with the right answers, thus allowing the TV instructor to confirm that they were correct. This learning-by-doing technique proved to be significantly better than the conventional lecture approach. The student helps in the preparation of this new type of instruction by constantly reacting to the specially prepared material thereby letting the instructor know whether the material was adequately prepared to enable him to perform correctly.

A third study concentrated on students' interest in science and their performance of experiments on their own after science telecasts. The techniques designed to stimulate extracurricular activities were judged effective when students actually performed experiments they had seen demonstrated on TV. Two techniques that proved effective were the use of student demonstrators rather than an adult demonstrator and the provision of kits and instructions needed to perform experiments at home. Fifteen percent more students who had watched fellow students demonstrate experiments on TV performed experiments on their own than did students who watched an adult instructor perform the same experiments. Students were also given kits to perform experiments in one of three ways. Some were given a kit of their choice automatically. Others were given postcards with which to write in for a kit. Still others had to provide their own postcard to write in for a kit. The more easily available the kit was, the more likely were students to perform an experiment. These were the percentages of students in each of the three groups who reported doing an experiment: 89%, 69%, and 37%. Results indicated that the more readily available the wherewithal to perform experiments, the more likely were students to be stimulated to perform them. Here again student performance was used to decide on the effectiveness of instructional techniques, this time techniques designed to encourage extracurricular activities.

Thus, in the three types of studies, student performance was effectively used before, during, and after TV lessons as a means of evaluating the adequacy of and as a means of improving televised instruction. More effective use of educational television can result from systematic attention to its methods for stimulating appropriate student responses and for altering or revising instructional programs until students do, in fact, attain the capability of making these responses.

INTRODUCTION

The design of instruction for the successful attainment of educational objectives depends to a considerable extent on careful and systematic attention to student responses. Student responses can in a sense be considered the building blocks of any program designed to teach. Instructional procedures and materials need to be devised which will stimulate appropriate student responses, and only when students do in fact respond appropriately can the procedures and material be said to be adequate. Appropriate student responses with which instruction must be concerned can occur, first of all, during the course of instruction. Students may be called upon to answer questions or to complete statements begun by the teacher or even to select a correct answer from a number of options. Such student responding during the course of instruction is encouraged because it is likely to contribute to effective learning. At the conclusion of a single or several periods of instruction the student may again be encouraged to respond appropriately, this time to tests designed to measure how well he has acquired knowledge of facts or understanding of concepts. Students may also be encouraged or stimulated to engage in extracurricular activities later at home. Writing reports, reading, or performing experiments may serve to facilitate interest in subject matter and to contribute to further learning. The responses students make following instruction, as well as during instruction, thus provide a tangible measure of the effectiveness of instruction.

Student responses can serve learning, testing, or motivational functions. Whatever their function, an essential goal of instruction is to elicit responses that are appropriate. A large share of the responsibility for eliciting such appropriate responses rests with those who plan and administer the curriculum. This means more than merely saying that the job of the teacher is to teach. It means that for instruction to be effective, teachers must pay systematic attention to all the responses (or achievements) they expect of their students and to the stimuli (or materials) they present in order to encourage them to make those responses. If students fail to respond or to respond appropriately, it is most likely because they were not adequately prepared to do so. The quality of instruction is, perhaps therefore, best evaluated in terms of what the student does

rather than in terms of what the instructor does. In this connection, it matters little whether instruction is offered "live" in the classroom, on TV or film, or by teaching machines. All media of instruction have the responsibility for preparing the student to be able to respond in ways that reflect educational objectives.

The studies reported in this series have explored several techniques for using student response to improve televised instruction. The pedagogical advantages of television afforded by the techniques it can employ would make it highly important to include television together with other new media in the nation's plans for educating growing numbers of students. However, there is currently little basis for predicting exactly what the structure of education will be like in the future; there is little certainty as to the optimum role to be played by television, teaching machines, films, or direct instruction by classroom teachers. Hopefully, each will play the role for which its distinctive capabilities best prepare it. The ultimate assignment of instructional functions to the various media should depend ideally on what each is best able to do. Where overlaps in capability occur, other considerations, administrative or logistical in nature, may be used in the final determination of how functions are to be allocated.

The distinctive advantages of television as an educational medium appear to be essentially logistical in nature. A single program source can provide instruction for large numbers of students within a given locality and, as in the case of the use of airborne transmitters, potentially across state boundaries. When recorded on film or on tape, lessons can also cross temporal as well as geographic boundaries. Lesson material and presentations that meet high quality standards can thus be shared widely. Large scale and repeated use can result in relatively small per student costs, even though the best resources are devoted to the implementation of instructional programs.

One factor strongly contributing to its ability to stimulate appropriate student responses is the television medium's highly flexible audio-visual capability. Both sight and sound can be used to complement one another and to heighten the effectiveness of instruction. More important, television, like films, can make dynamic presentations of process, motion, or event. In science instruction particularly, where demonstrations play a key role, this capability is unusually valuable.

With its logistical advantages and its rich audio-visual capabilities, educational television would appear to be a leading resource for helping to meet the burden of instructing large numbers of students in a growing population. The purpose of several studies described in this series of reports and reviewed briefly in this volume has been to demonstrate, while taking advantage of TV's distinctive capabilities, several ways in which student responses may be used both to improve and to assess the quality of instruction that TV can offer.

RESEARCH APPROACH

Televised lessons in a science series prepared for Junior High School students in the greater Pittsburgh area were used as the vehicle for the research reported here. The series consists of 25-minute lessons on general science presented on the air three times a week during the entire school year. Approximately 120 classes in public and private schools within the reception area of Metropolitan Pittsburgh Educational Television Stations (WQED-WQEX) regularly watch the series. Lessons are prepared by a team consisting of a Junior High School science teacher and the production staff of WQED.

There are at least three advantages in using as a context for research studies a series of lessons which students regularly view. First, it is efficient in planning the preparation of a lesson for a particular experiment to know what has already been taught and what will be taught in subsequent lessons. Second, there is the related advantage that lesson content can be developed at a level of difficulty or complexity selected on the basis of what students already know. Third, students are accustomed to learning over television so that when they participate in an experiment it does not represent a sudden introduction to a new medium of instruction. This tends to reduce the likelihood of spurious novelty effects which might make interpretation of results equivocal. Fourth, control is also possible over the influence that prior exposure to experimental variations might have on performance by students participating in later experiments.

Experimental versions of lessons were generally shown on a UHF channel made available to the experimental classes by utilizing UHF converters. (The regular series was scheduled and customarily watched on a VHF channel.) Experimental lessons, introduced at various times during the regular science series, were prepared by the research staff in collaboration with subject-matter experts. Lessons were prepared on the basis of detailed statements of objectives. At the same time, the features under investigation were systematically introduced into the experimental version of a lesson and omitted from a "control" version. At the end of the planning stage, both versions of the lesson were stage rehearsed in the studio and were either filmed or taped for showing at a later, regularly scheduled date. In most experiments both the experimental and control versions were filmed. In

a few experiments, one version was on the tape and one on film. When this was the case, the taped version (which was presumably of better pictorial quality) was used for the control lesson, in order to avoid favoring the experimental lesson. Thus any superiority of the experimental version shown by test results could not be attributed merely to the adventitious factor of superior pictorial quality.

In the presentation of the lesson, the TV instructor generally worked from a teleprompter (see Figure 1). Since the instructors participating in the studies were experienced at TV instruction, including the use of teleprompters, generally spontaneous-appearing performances were obtained. Along with the advantage of this apparent spontaneity, there was also the advantage of systematic, detailed control of the material presented in both experimental and control versions of the lessons. In this way, the adventitious introduction of material into either version was precluded, and the relative effectiveness of the two versions could be accurately assessed in relation to the specific, pre-designated differences in presentation which it was the purpose of the study to investigate.

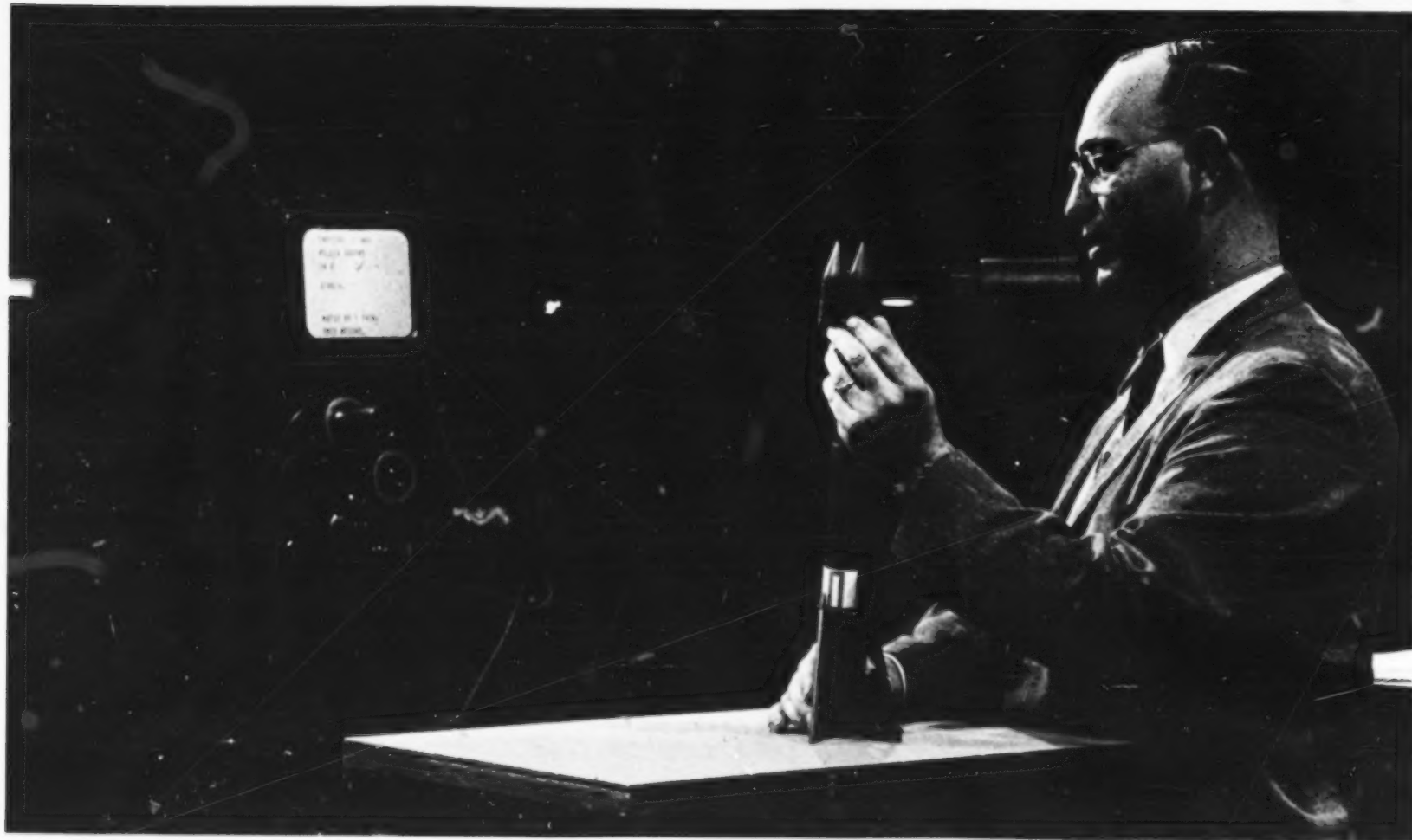


Figure 1

Metropolitan Pittsburgh Educational Television Station is a dual channel facility (WQED-WQEX) which provides an unusually good opportunity for controlled experimentation of the type used in these studies. The experimental version of a lesson was telecast over one channel and the control version simultaneously telecast over the second channel. Reception in the schools participating in these studies was judged to be adequate and to be comparable on both channels -- thus favoring neither experimental nor control groups. Schools selected for inclusion in the study were those which could receive both channels (UHF-VHF) adequately. Geographic rather than demographic factors were associated with reception and hence, although the selection of the sample was not strictly random, no systematic biasing factors are believed to have been operative. Classes were matched on the basis of grade, sex, and intelligence. They were similarly matched as fully as possible on the basis of general viewing conditions and size of screen. In addition, suitable randomization of assignment to control or experimental programs was accomplished by one of two methods.

Method No. 1

In those situations where it was felt that following the telecast interaction of students who had seen alternative versions of a lesson might influence the test results, entire intact classes from different schools were selected for participation. One class was treated as an experimental group, and its matched counterpart as a control group. Each intact class was matched on the basis of average IQ with another intact class in another school, and then one member of the matched pair was assigned at random to each treatment. The class, rather than the individuals within the classes thus became the unit of sampling. Accordingly, subsequent analyses of data were based on the number of classes used and not on the number of students within them. This procedure, while a safe one, is not optimally efficient for testing hypotheses, and it is administratively cumbersome to sample large numbers of classes. Accordingly, the second method of sampling, when feasible, was employed.

Method No. 2

In those situations in which interaction following a telecast was less likely, students within a single class were paired off in advance and usually matched on the basis of sex and IQ. One member of each pair was then assigned on a random

*basis to the experimental group, and watched the experimental program in one room on one of the TV channels, while the other pair member watched the control lesson on the other channel in another room. The individual student rather than an intact class thus became the unit of sampling in this instance, resulting in the statistically more efficient use of the number of students participating in the experiment. With this method, several such sub-divided classes were used in each experiment.

Following the telecast, students in both the experimental and control groups took identical achievement tests. Tests were constructed on the basis of the same lesson objectives that guided the preparation of the lesson content. The tests were intended to sample all the material which students watching either version of the lesson could be expected to learn from the lesson. Comparison of test results provided a measure of the relative effectiveness of experimental and control versions of lessons. In some instances, experiments were repeated with different lesson content, different instructors, and different students to afford a broader base for the generality of the findings.

The specific experiments performed were concerned with three different uses of student response to improve televised instruction: (a) to pre-test televised lessons; (b) to improve learning effectiveness; and (c) to evaluate and improve the incentive value of TV lessons. These three uses of student response, which are described in detail in prior reports in this series (1, 2, 3, 4, 5, & 6) and in a film report (7) will be reviewed briefly in the sections that follow.

THE USE OF STUDENT RESPONSE: TO PRE-TEST AND IMPROVE TV LESSONS

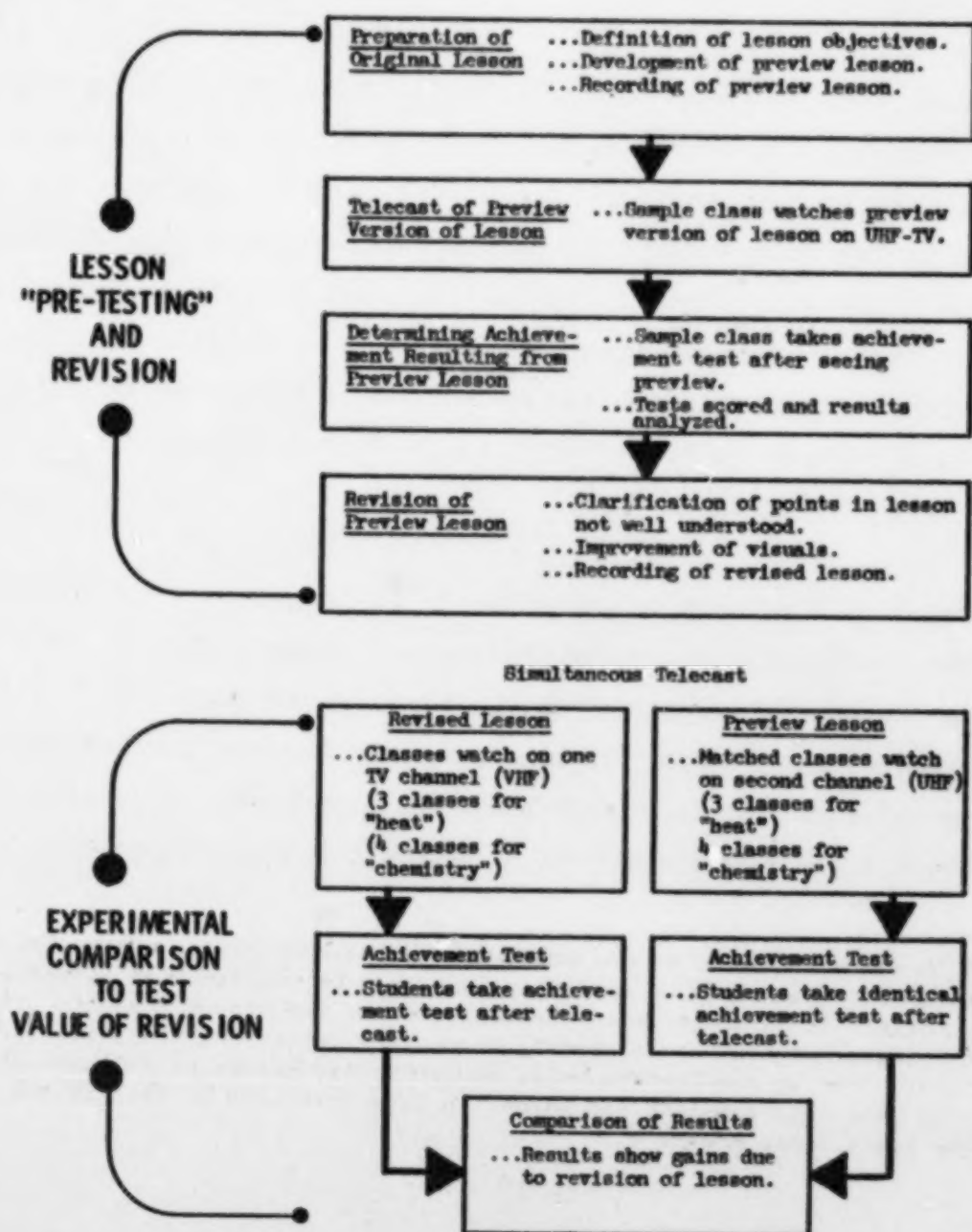
The classroom instructor has the opportunity to modify his lecture presentation while it is in progress. Particularly with a very small class, he can often do this rather effectively on the basis of student responses to his presentation. Student answers to his questions and the questions they raise guide him in repeating, restating, or rephrasing his material. With alterations in presentation, he can accommodate the needs and abilities of his particular audience. When students fail to understand or even misunderstand particular points, he can provide the needed correction. Feedback from students may thus provide the classroom instructor the opportunity to maintain some measure of control and selective guidance over student learning.¹

The TV instructor, in sharp contrast, lacks face-to-face interaction with his students and typically receives feedback only after his presentation is over. Only then, at best, does he know whether his presentation was suitable for his particular audience. He may then attempt to provide correction during subsequent instructional sessions. However, there is theoretical and empirical support for the position that it is best to correct wrong responses as soon after they are made as possible. Perhaps even more efficient are attempts to insure that students are capable of making correct responses than to be forced to have to correct their wrong responses once they are made.

The purpose of a first set of experiments in this series of studies was to demonstrate the feasibility and effectiveness of using a special form of student response to enable the TV instructor to build understanding into the lesson he is preparing and whenever necessary to take steps to forestall misunderstanding. As described in greater detail in Report No. 1 in this series (1), students in a sample class watched a preview version of a lesson televised especially for them.

¹This degree of "feedback" control to the instructor diminishes greatly, however, as the size of the class group increases. It is really optimal only in the tutorial situation when the instructor can tailor his instruction to the needs of the individual student. In the large lecture hall the degree of control is greatly attenuated and may be but little better than in TV instruction. Even in the lecture hall, however, some degree of feedback is available -- even though it is both less complete and harder to take advantage of than in the tutorial situation or the small class group.

Their responses on an achievement test following the telecast provided the TV instructor with feedback he needed to determine how well the level of his presentation matched the level of ability of students who watched it. Student performance on the achievement test indicated which points were adequately covered and which points were inadequately covered for the particular audience. Based on an item-by-item analysis of the achievement test and on a point-by-point review of the lesson, the research staff was able to develop and recommend to the TV instructor ways of improving the lesson. A new lesson was prepared including the suggestions that were based on student feedback to the instructor available from test results. At a later date, both preview (original) and revised versions of the lesson were simultaneously telecast and were watched by intact, matched classes. An identical achievement test was administered to the group which watched the preview version and to the group which watched the revised version. The entire procedure of lesson preparation, tryout, revision, and experimental comparison is summarized in the following schematized diagram:



This procedure was followed in two separate experiments, one involving a lesson on "heat" and one on "an introduction to chemistry." Analysis of results comparing preview and revised versions revealed that in both experiments students who watched the revised version scored significantly high on achievement tests than the students who watched the preview version. For various test items, improvements over the preview version ranging from six to twenty-six percent were found, as measured in terms of the differences between the percentages of correct answers on each item achieved by students watching the revised and unrevised versions of the program.

Figure 2 summarizes the average results (the percentage of test points obtained out of the total possible) obtained for the lesson on "heat."

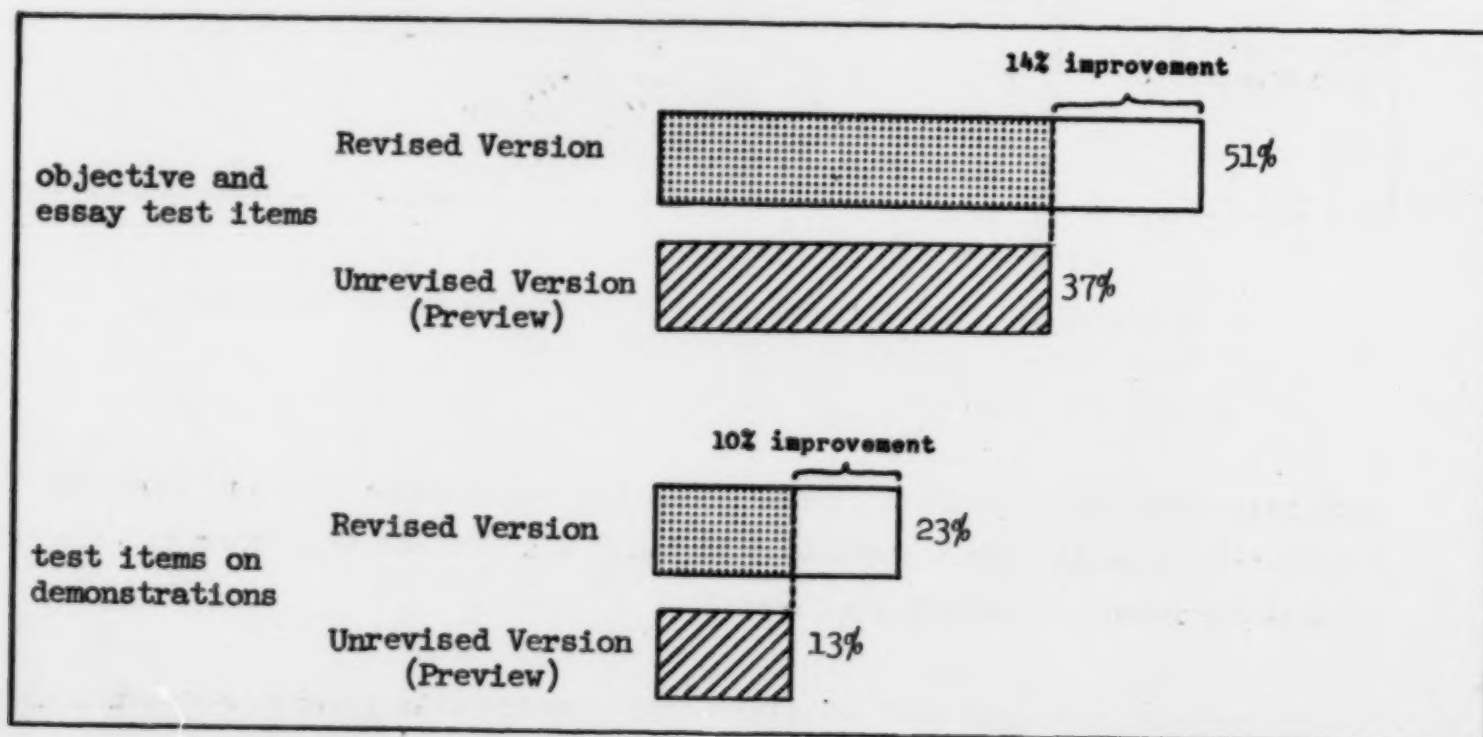


Figure 2
Achievement Test Results for Revised and Preview Versions
of Lesson on Heat²

²Length of bars indicates average percentage of correct test answers for each group on each set of items.

Figure 3 similarly summarizes the average results (the percentage of test points obtained out of the total possible) obtained for the lesson on "chemistry."

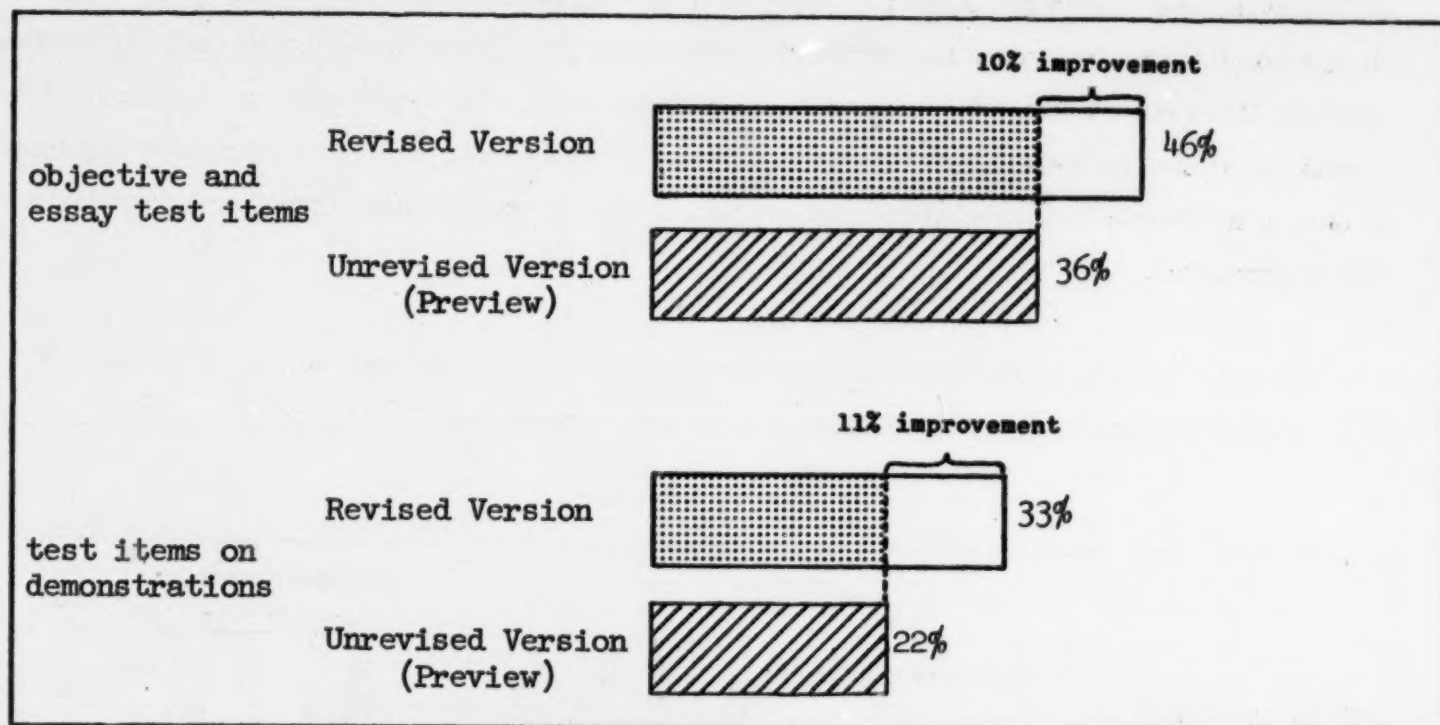


Figure 3

Achievement Test Results for Revised and Preview Versions of Lesson on Chemistry²

Both illustrate the amount of improvement that was brought about by revising the lesson. In general, there were statistically significant improvements in test results for the revised version.

The method of tryout and revision holds considerable promise for the preparation of effective TV lessons. With cumulative stages and with refinements in technique, more substantial gains than those reported here should be readily possible. The key features of the procedure of tryout and revision for TV instruction appear to be these: (a) the explicit specification of lesson objectives including facts and concepts students are expected to acquire; (b) the development both of lesson content and of achievement test items covering specific points in the lesson

²ibid.

objectives; (c) the tryout over television (closed-circuit television is a distinct possibility here) of the prepared lesson with a sample audience from the population of classes that is ultimately to be given the lesson; (d) the administration and analysis of the achievement test following the preview showing of the lesson; (e) discussion with the instructor and TV production personnel of specific points, revealed by the test data, which were inadequately taught in the lesson, and of student misconceptions which could be forestalled. (The nature of student misunderstanding, as revealed through analysis of incorrect test options most frequently endorsed, aids in the reconstruction of specific parts of the lesson to forestall misunderstanding; item analysis may also suggest the nature of changes in presentation that can also maximize student understanding.); (f) the lesson is revised in the light of this analysis and shown on the air at its regularly scheduled date.

Pre-testing a preview version of a lesson in this study provided the TV instructor with needed information about the effectiveness of his lesson. Comparison of student performance on specific items in an achievement test, administered following the preview of the lesson, indicated which specific parts of the lesson were too difficult for students to learn or understand. This empirical evidence, based on the test performance of a preview audience (in this case seventh and eighth grade students) enabled the TV instructor to prepare a revised and improved version of the lesson.

The worthwhileness of the pre-test and revision procedure is indicated by the fact that the over-all results show general superiority for the revised versions of both the lesson on "heat" and the lesson on "chemistry." The replication of the experiment using different lesson content, different instructors, and a different sample of classes from the same population of classes, suggests the applicability of the lesson pre-testing method to a range of diverse lesson content. The particular advantage of this technique is the use of a sample audience resembling the ultimate audience in all important details (such as age and intelligence) for pre-testing purposes. The lesson can thus be tailored for a specific audience. The number of students to be taught and the number of years lessons will be used are, of course, factors to consider in determining how much money and effort can be devoted to successive stages of tryout and revision. Each stage of tryout and revision should offer the potentiality of a substantial increase in student learning and understanding.

With the use of the lesson pre-testing method, the absence of student-instructor interaction is no longer a primary handicap. The TV instructor can detect student misunderstanding and forestall it in the revised presentations so as to build student understanding. He can explicitly and systematically chart the path the student should follow in acquiring new knowledge. The limitations in the resulting presentation after successive revisions should be only those inherent in the lecture method of presentation itself (whether used in the classroom or on TV). The next section of this report deals with ways in which some of these limitations can be partly overcome.

THE USE OF STUDENT RESPONSE: IN "PROGRAMMED" TELEVISION INSTRUCTION

A tutor instructing an individual student has the opportunity to maintain control over the student's learning behavior. He can do so by stimulating the student to respond and by providing an appropriate context in which the student can respond appropriately. Also, he can reinforce or reward the student for correct responses. These are features of instruction considered by many investigators essential for the systematic guidance and control of learning. On the other hand, in the classroom the teacher even though she perhaps encourages considerable recitation, is not able to maintain optimal control over all these factors for all students. With even moderately large classes, the teacher cannot, typically, encourage all students to respond to each of the key points in the lesson, nor is she readily able to prepare students methodically to be able to respond correctly in an appropriate context. Moreover, she often does not provide feedback to students consistently or promptly.

There is little reason to expect that televised instruction by the conventional lecture method will produce even the partial control that the classroom teacher can exercise. For, without the possibility of student-teacher interaction, the TV instructor has generally had no opportunity to encourage students to rehearse responses, to prepare them with adequate cues to respond correctly, or to provide them with feedback about the correctness of their responses. The physical separation of TV instructor and classroom students has tended to preclude the systematic control over student learning behavior. The purpose of several studies in this series has been to experiment with procedures for overcoming this drawback and to evaluate the feasibility of building into TV lessons elements of instructional control.

Research on teaching machines and prior studies on the effect on learning of active student response during instructional films have provided a model and an example of how instructional control can be more systematically achieved. Teaching machines of varied physical configurations have been designed which function in such a way as to: (a) control the display of stimuli to which students are expected to respond; (b) provide an opportunity for students to respond to the stimuli and

to record their responses; and (c) provide students with feedback about the correctness of their responses. In such an arrangement, students are encouraged to learn by doing. The physical equipment serves the function of stimulating the student to respond, or in other words, to facilitate the student's learning-by-doing. The function served by the "program" or material used in the device is to stimulate the student to make or construct particular responses he is expected to acquire. Since it seems likely that learning-by-doing is most efficient and effective when students make mostly appropriate, correct responses, the program is so prepared that there will be a high probability that students are able to come up with correct responses.

To illustrate, students might be presented with this incomplete sentence and be expected to complete it correctly:

Atoms recombine in chemical reactions to
form new m o l _ _ _ _ _ s.

There are cues within the sentence (the letters "mol") which aid the student in constructing the correct verbal response "molecules." Of course, the mastery of prior material is also necessary for the student to be able to complete the appropriate response correctly.

The general approach in preparing students to be able to master any segment of a lesson consists of the methodical planning of all segments. Lesson content is reduced into small steps or segments. Within each step are seeded cues or prompts which enable the student to master that step (i.e., to make an appropriate, correct response). Steps themselves are sequenced in such a fashion that mastery of a given step paves the way for mastery of the next step. Each step is intended to take the student ahead slowly, requiring him to master only what he is capable of mastering at that point. The student's mastery of lesson content, as evidenced by his ability to make correct responses in appropriate contexts, is thus built up gradually. The gradual attainment of new knowledge is obviously also found in conventional instruction. What characterizes programmed instruction is the deliberate and careful preparing of students to insure a high probability that they will succeed at each step, thereby heightening the efficiency of the course of learning. Moreover, students are also immediately and consistently provided with prompt feedback as to the correctness of each response. This serves to reinforce the correct

responses they make and to correct any incorrect ones immediately.

The techniques and principles of programming learning sequences in teaching-machine instruction are being widely investigated. Research in many areas has provided growing evidence of the feasibility and effectiveness of programmed self-instruction. The purpose of the present set of studies has been to assess the feasibility and effectiveness of applying programming techniques to televised instruction to groups. One of the chief factors that calls for separate research on the applicability of programming to TV is the difference in the capability of a teaching machine and television to accommodate individual differences in student ability to learn. In teaching-machine self-instruction, in addition to steps taken to gear the level of presentation to a particular class of students, each student works through the instructional program at his own rate. Since each student can select the pace at which he progresses through a program, bright students can proceed through and finish a program rapidly, while average or lower than average students can take as long as they need. This opportunity to proceed at a self-selected pace contributes to a high probability of correct student responding. Television instruction, on the other hand, proceeds at a fixed, instructor-selected pace. Instruction continues whether or not any individual student can respond correctly at a given step in the lesson. The more heterogeneous in ability the group receiving televised instruction, the less adequately will the rate of presentation built into a lesson match the ability of the group.

Despite this drawback, elements of instructional control can be built into televised lessons and can be expected to increase the efficiency of learning. Students can be stimulated to construct responses in the presence of appropriate cues and they can be provided with feedback (by being told after they have responded what the correct response should be). As part of this series of studies, several experiments were conducted which provide general support for the feasibility and utility of employing such procedures (2, 3, & 4). In one experiment, the revised and improved conventional lecture on "the effects of heat" discussed in the previous section was now compared with a newly prepared "programmed" version of the same lesson. The lesson material was broken up into small steps or segments and steps were then logically sequenced. Cues were seeded within each step which were intended to aid students to be able to construct correct responses.

Students watching the programmed version of the lesson were encouraged to respond actively by saying the answer out loud. The following instructions, designed to provide such encouragement, preceded the lesson:

"I am heating this metal strip with the flame from a bunsen burner. As the strip gets hot, it begins to bend. Why did it bend? Later in our lesson we'll find out why and we'll also find out what happens to any kind of object when we apply heat to it.

"To help you to understand the lesson better, every now and then I'm going to pose a question and wait for you to answer it before I give the answer. Every time I pose a question for you to answer, I'll flash a question mark on the screen like this (?). When you see the question mark, say the answer right out loud. See if you can say the answer out loud before I tell you what it is. O.K.?"

To heighten the stimulus to respond and to identify the occasion, a question mark was flashed on the screen (see Figure 4).

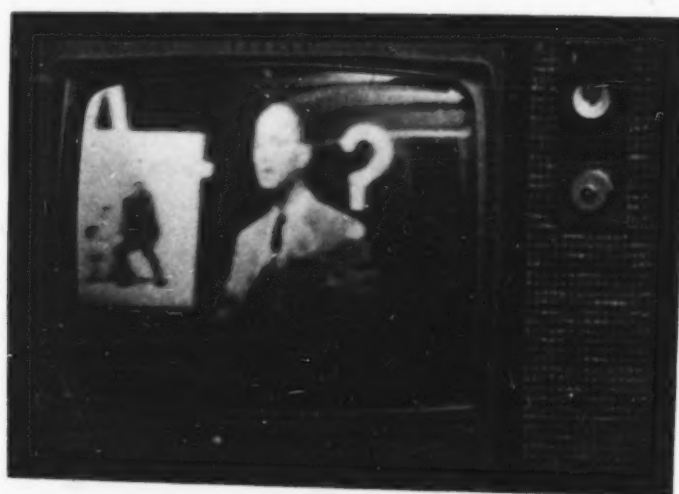


Figure 4

The question mark accompanied all of the instructor's pauses. In addition, during the pause the instructor occasionally added further remarks such as: "what?", "how many molecules?", "how?", or "what kind of bar?". All these techniques were intended to encourage students to respond. The programming of the material was intended to elicit specific, correct responses as planned in lesson objectives. The program was, indeed, pre-tested to determine whether or not students could respond correctly and when it failed to do so, it was revised accordingly.

During the experiment itself, the conventional lecture which made no systematic or methodical effort to stimulate student responding was contrasted with a programmed lesson which did. The programmed lesson had been sequenced, pre-tested, and required active student responding. Results from an identical achievement test administered to students who saw either of the two versions of the lesson were analyzed and were found to show differences between the two groups. Students who watched the programmed lesson and responded actively to it received significantly higher test scores (averaging 64% correct answers) than did the students who passively watched and listened to a conventional TV lecture (averaging 59% correct answers). A more detailed analysis of the results showed that these differences in performance were related to student intelligence. Only among high IQ students was there a significant difference between students who watched and responded actively to the programmed lesson and those who merely watched the conventional lesson. The margin of improvement for the high IQ students (shown in Figure 5) was considerably larger than that for the entire group of students.

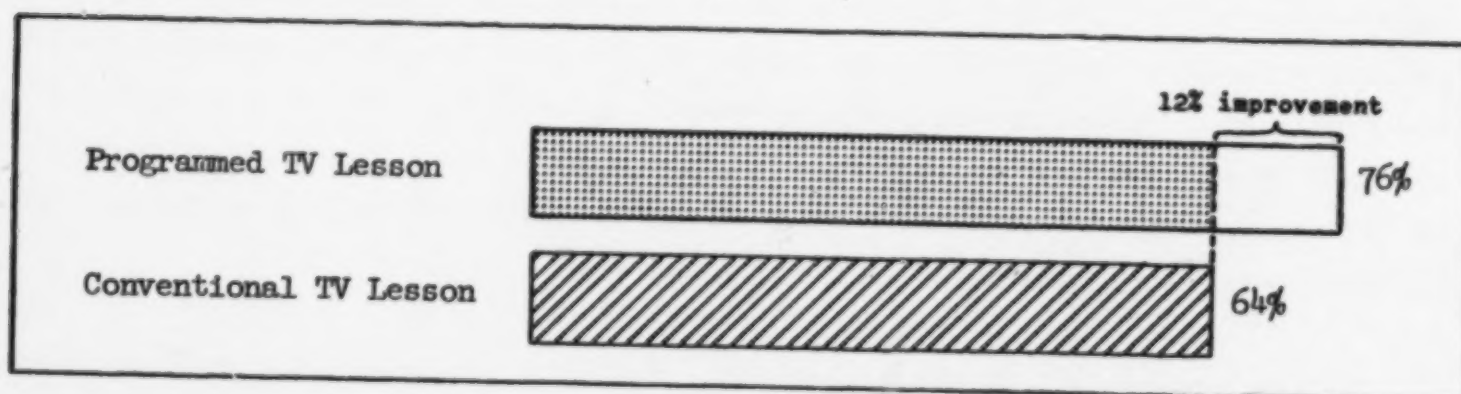


Figure 5
Percentage of Total Test Points Attained on
Immediate Post-Test by Students Watching
Programmed and Conventional TV Lessons
(Lesson on Heat)
High IQ Students Only

On an immediate post-test, there were no significant differences among low IQ students, and on a test of retention two weeks later, the low IQ students who watched the conventional lesson even scored significantly higher than did students who watched the programmed lesson. These results were interpreted to mean that the programming of lesson content may have been adequate to elicit correct responses

from high IQ students only. These results tend to support the view that active responding to programmed instruction can be effective but that it is difficult to prepare programmed material for students of widely differing ability who must receive instruction from a single program source. Factors contributing to the difficulty students might experience in trying to construct correct responses appear to be: (a) the level of complexity of lesson content itself; (b) the fixed and uniform rate of presentation for all students, which precludes students taking as much time as they individually need for responding; and (c) the use of oral presentation in which, once the lecturer has spoken, the stimuli are available only from memory and not directly (perhaps reducing their ability to prompt correct responses). One potential solution to the individual difference problem would be to use more than one program source. Separate program sources for relatively homogeneous ability groups might adequately accommodate differences in ability and produce efficient learning. If the number of necessary subgroups does not become too high, and if there are still large numbers of students who can be served at the same time by each of the separate program sources, the logistical advantage of television could still be maintained along with the pedagogical efficiency made possible by the programming of learning sequences.

Further experiments in the series were conducted to explore the role of other variables in programming televised instruction (3 & 4). Results of several separate experiments support the position that it is not enough merely to require students to respond. They must be adequately prepared to respond. Preparation of learning sequences and pre-testing their ability to stimulate correct responses appear to contribute to the effectiveness of programmed instruction. Further, it also appears to be beneficial for learning if students are required to make overt responses (oral or written) to the sequenced and pre-tested program. Figures 6 and 7 (for tests of acquisition and of retention of knowledge) illustrate the added advantage of making overt responses to programmed material over merely passively watching and listening to the same material.

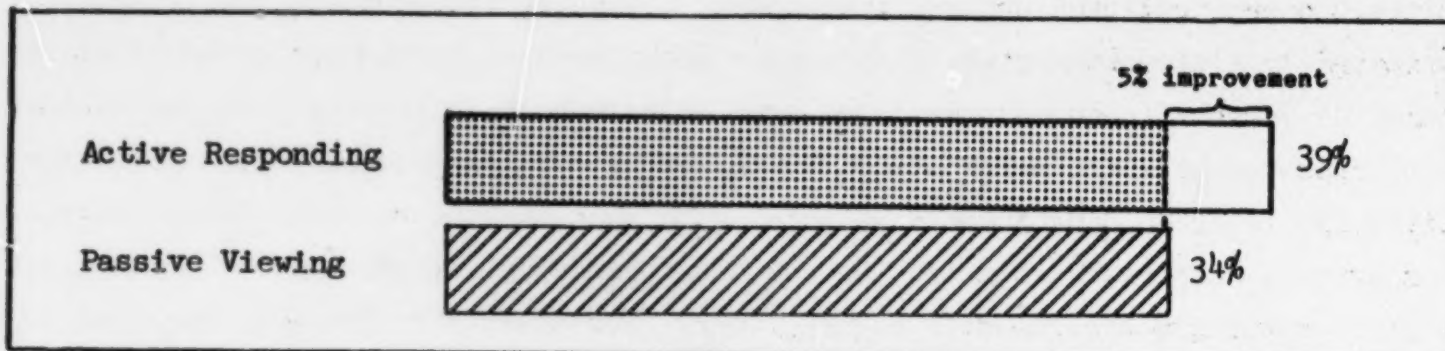


Figure 6
 Percentage of Total Test Points Attained
 by Students Making Overt, Active Responses
 and by Students Passively Watching Identically
 Programmed Material
 (Test of Acquisition: Lesson on Movies)

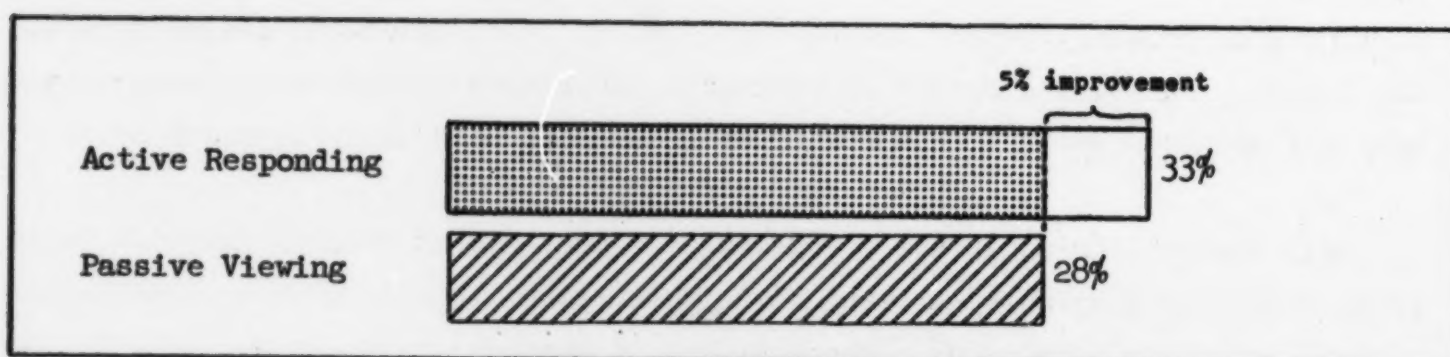


Figure 7
 Percentage of Total Test Points Attained
 by Students Making Overt, Active Responses
 and by Students Passively Watching Identically
 Programmed Material
 (Test of Retention: Lesson on Movies)

With advances in the state of the art of programming for groups and with the use of more homogeneous groups (for whom the difficulty level of the material, the method of presentation, and the rates of presentation would be suitably tailored) more substantial gains than those demonstrated here should be possible.

Additional experiments were conducted to compare modes of responding alternative to overt written or oral responses. Since overt responding (particularly writing) is time consuming, limitations are placed on the amount of material that can be covered in an instructional hour or half-hour. Therefore, it was decided to compare the learning of students who merely read programmed material or attentively listened to programmed material with that of students who were required to construct responses actively. Somewhat surprisingly, in view of the earlier findings supporting the value of active, overt (and covert) responding, no significant differences were found between implicit responses (reading and attentive listening) and active, overt responding to the same programmed material. It was suggested that further research on the role of these variables would be desirable. It was, however, concluded that even if future research confirms the comparative value of implicit responding to programmed material, it might still be desirable to require overt, written responses. A written record of responses is tangible evidence that control over student responding has been obtained. This may be particularly important in televised instruction where the student may be attracted or distracted by competing stimuli in the classroom. Without a record of responding, there would be no way of knowing whether the student did, in fact, attend to and respond to the lesson. Further, a record of responses might also provide the classroom teacher with a diagnostic measure of the kind of individual help students might need.

This series of studies has demonstrated a dual use of student response to improve televised instruction. During the developmental phase of lesson preparation, student responses were used as the criteria of whether or not lesson material had been adequately programmed. Student responses were also encouraged under controlled conditions during actual instruction in order to increase learning efficiency. It appears that this dual use of student responding can materially improve the quality of televised instruction. However, much more remains to be learned through future research about how to maximize the value of these ways of utilizing student response to improve instruction. Of especial importance are further explorations of procedures for improved accommodation of individual differences and further study of the relative value of overt responding, implicit responding, and combinations of the two which would attempt to combine the potential advantages of each mode of response.

THE USE OF STUDENT RESPONSE: AS A MEASURE OF TV LESSON INCENTIVE VALUE

Extracurricular science activities can be essential elements in effective science education. Doing an experiment at home or in school following TV science lessons may both serve to enhance understanding of science principles and also to stimulate further interest in science. In much the same way that the instructor must find ways to prepare the student to respond correctly during instruction, he may also need to find ways to prepare him to perform experiments on his own effectively. This is important in order to teach how to do experiments and to give them an understanding of the scientific principles involved. It is also important for future student activity, for we may expect that successful completion of experiments can be reinforcing for further participation in science activities. But how can initial participation in science activities at home or in school most effectively be brought about? The purpose of a third type of study has been to evaluate several techniques designed to stimulate initial student follow-up activities at home (6).

Three procedures were evaluated to determine their effectiveness in stimulating student performance of experiments they had seen demonstrated on the air. The procedures were employed in conjunction with what was called a "Fun Day" program. The program consisted of six brief demonstrations of experiments that would be relatively easy for seventh and eighth graders to do. The six experiments selected illustrated the following phenomena or principles: (a) magnetic lines of force; (b) surface tension in liquids; (c) Pascal's Law on the distribution of pressure; (d) compression and rarefaction of energy waves; (e) equalization of forces; and (f) transmission of light waves. Two of the procedures designed to stimulate follow-up activity were incorporated in the televised presentation itself and the third was introduced in the classroom following the telecast.

One of the procedures incorporated into the televised lesson itself was the use of student demonstrators. Students from classes regularly watching the science series were selected and brought into the studio (see Figure 8).

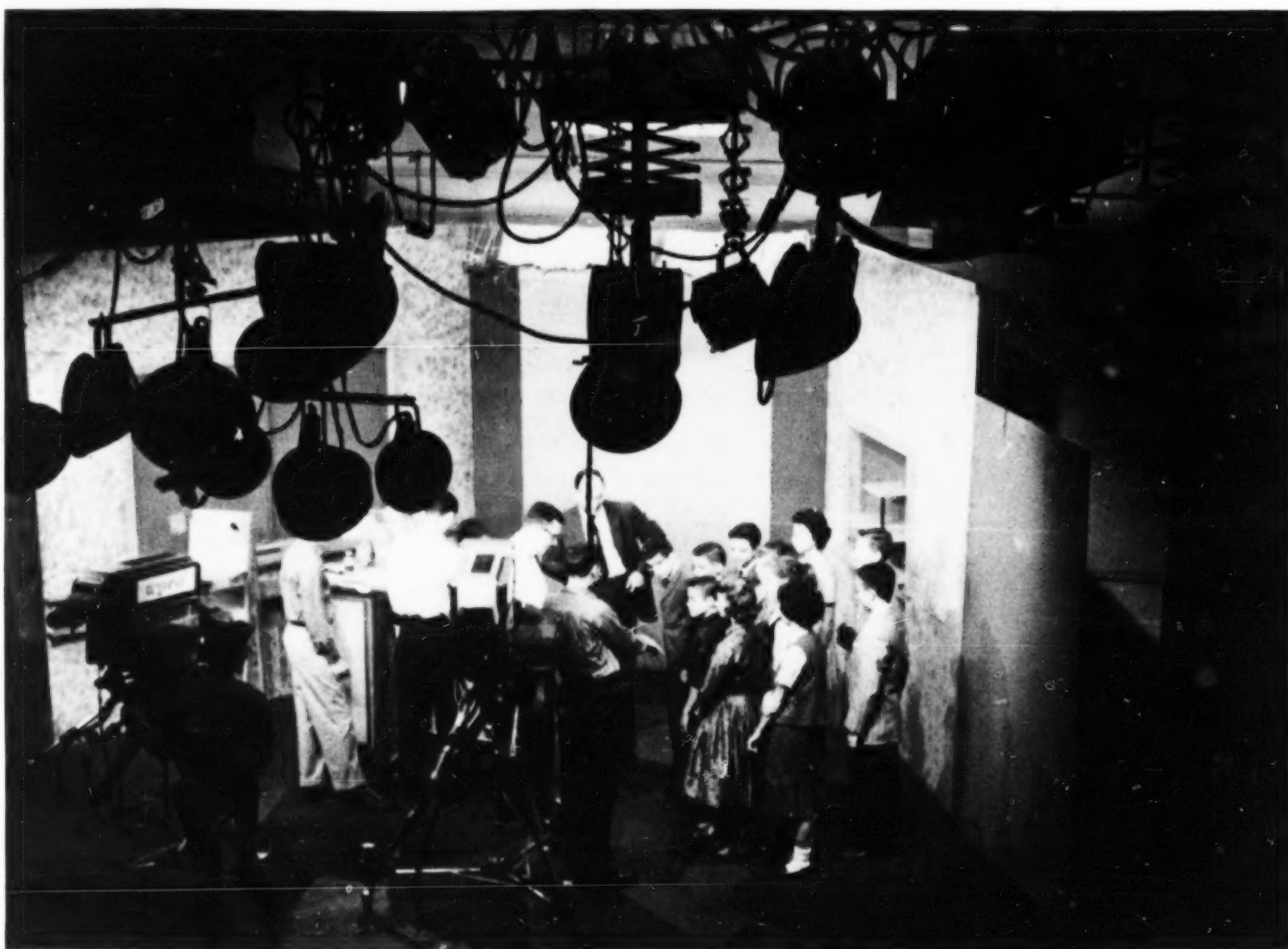


Figure 8

In the experimental version of the lesson, each of these students, who were the same age as those watching the program, performed one of the six experiments while the off-stage instructor described and explained the experiments. In the control version, the adult instructor performed and explained the same experiments. In both versions, the TV instructor described the experiments as easy to do. At the end of the experimental version he told students in the classroom:

"These students found these experiments easy and fun to do.
Why don't you try some of them at home?"

An analysis of student reports approximately two weeks after the telecast indicated that considerably more students who had watched student demonstrators

had performed an experiment on their own than did those who had watched the adult instructor demonstrate the same experiments. Significant differences found between these two groups are represented in Figure 9.

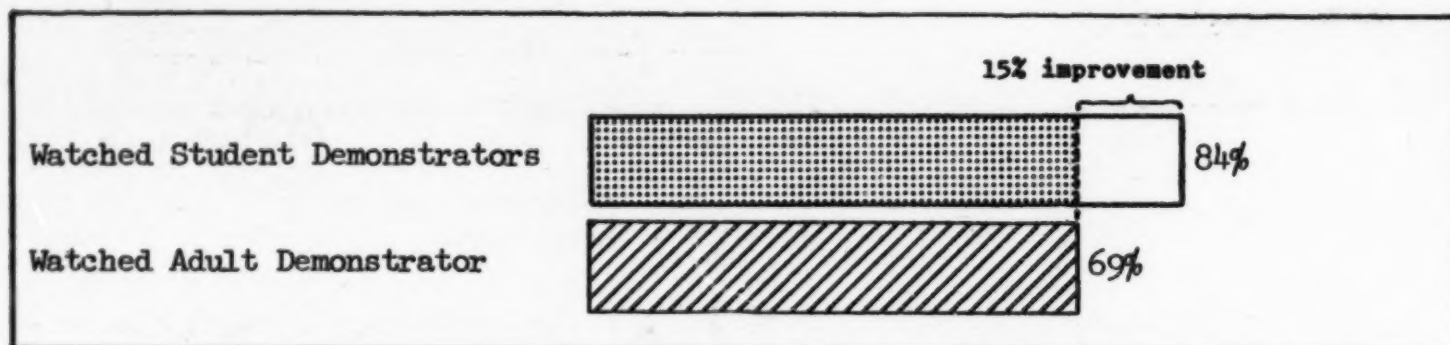


Figure 9
Mean Percentage of Students Reporting
They Had Performed an Experiment

A second procedure incorporated into the TV lesson itself (in the experimental or student version only) was the completion of only three of the experiments. The remaining three were left incomplete. The purpose of this procedure was to determine whether experiments that were begun but cut-off before they were completed and with only partial results shown would stimulate curiosity and interest in completing them.

An analysis of student nominations after the telecast of experiments they would like to try indicated that this procedure apparently had backfired. Since students who watched the control or adult demonstrator version saw the same six experiments (all completed), their nominations provided a measure of the relative popularity of the various experiments. Their nominations indicated that the three experiments left incomplete in the experimental version (but which they themselves saw completed) were more popular than the other three. Results of nominations by students who saw the experimental version containing the incompleted versions reversed this preference to a significant degree. A comparison of relative preference is shown in Figure 10.

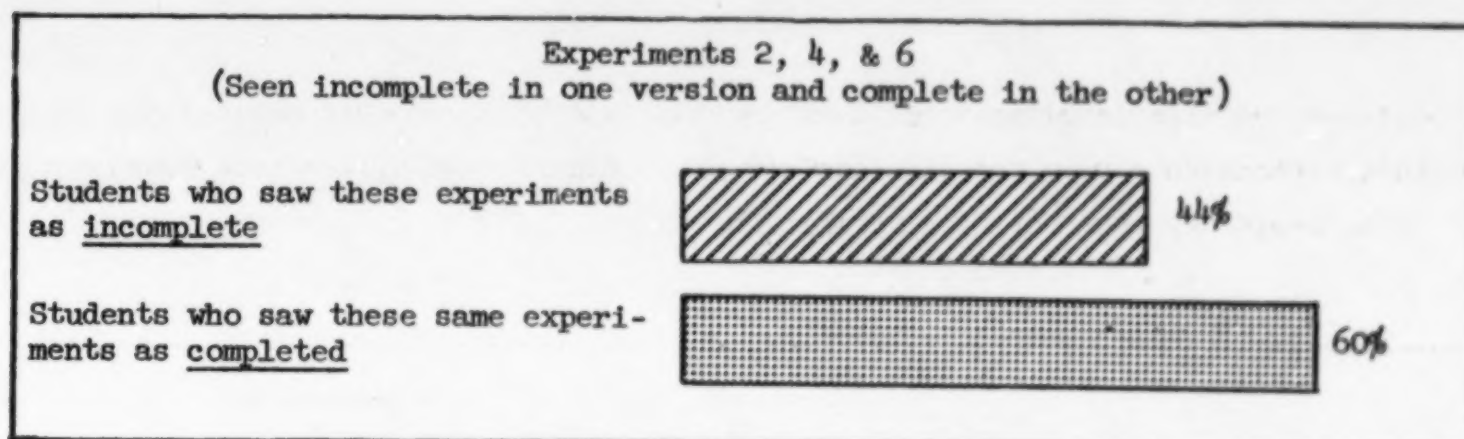


Figure 10

Comparison of Nominations of Experiments by Experimental and Control Groups

A third procedure, which was introduced in the classroom following the telecast, consisted of providing students with the "wherewithal" to perform an experiment. After students nominated the experiments they would like to try, kits with materials and instructions on how to perform each experiment were made available to students. These kits are depicted on page 28. The kits were made available in one of three ways. In one set of schools, students were automatically given a kit for the experiment of their choice. In a second set of schools, students were given postcards and informed that they would receive a kit for the experiment of their choice if they sent the postcard in. In a third set of schools, students were given neither kit nor postcard. Students in this last set were informed, however, that if they sent a postcard in (a postcard which they would have to provide themselves), they would receive a kit for the experiment they had chosen.

This procedure thus varied the degree of availability of the wherewithal to perform experiments. It was hypothesized that more directly available the wherewithal, the greater the inducement or incentive to perform an experiment. Results, as shown in Figure 11, bear this out rather strikingly in terms of large and statistically significant differences among the three groups.

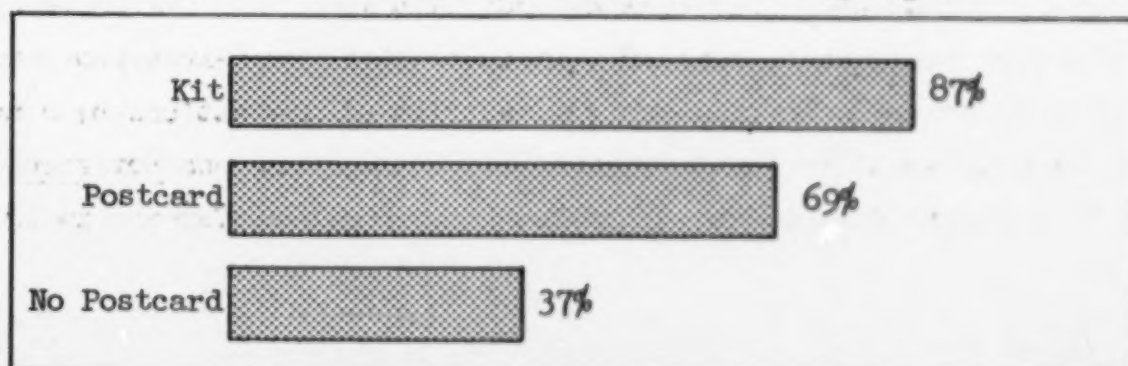


Figure 11

Mean Percentages of Students in Each Materials Category Reporting Performance of an Experiment



In summary, of the two procedures which were designed to stimulate initial interest in extracurricular science activities and which were incorporated or built into the TV lesson itself, only one proved effective. Seeing students who were described as being their own age (and who were visibly so) perform experiments appears to have been effective in encouraging other students to try experiments on their own at home. Presenting incomplete experiments in an attempt to whet student curiosity about possible outcomes appears to have had the opposite effect. It may be that students unfamiliar with the principles being illustrated and with experimental procedure prefer to work with the known rather than the unknown. As a way to stimulate initial interest, leaving the experiments incomplete seems to be ineffective. Particularly effective was the third approach. Providing wherewithal and instructions on how to perform experiments produced a high rate of student response. The more directly available the materials were, the more readily did students appear to follow through and perform an experiment on their own.

The implication of these findings appear to be that the more completely students can be convinced that they can perform experiments and the more directly they are encouraged with necessary equipment and instruction, the more likely they are to try doing experiments. School systems, it would appear, would do well to make appropriate materials as directly available as possible to be used in following up either television, teacher, or teaching-machine science instruction.

CONCLUSION

Student responses before, during, and after instruction have been used in various ways in the several studies conducted in this series to improve the quality of televised instruction. Before TV lessons were shown on the air, student responses were used for pre-testing purposes to evaluate the effectiveness of entire lessons. Student achievement on tests was used as a criterion measure of how well prepared the lesson was. Student responses were also used to evaluate the effectiveness of the various sequenced, separate steps within a lesson. In this case, the importance of correct student response at each step of the lesson was studied. During the pre-testing phase when student performance on the entire lesson or on a particular step was inadequate, the inadequacy was used as a guide in revising instructional material or presentation. During the lessons themselves, students were stimulated to respond actively so as to further the values of learning-by-doing. Particular effort was devoted to the preparation of lesson material to assure that students responded correctly. The principal preparation techniques consisted of programming methods derived from teaching-machine instruction. Students were also encouraged to respond after the lesson was over by engaging in extracurricular activities. Their actual performance was used as a means of assessing the incentive value of TV lessons. Only techniques that actually produced the student response of performing an experiment were judged to be an effective inducement to extracurricular activities.

The goal of instruction is to provide students with a behavioral repertoire of new responses that is indicative of new knowledge and understanding. To enable students to exhibit new responses for the first time, special efforts must be made, and when the correct responses do occur special steps should be taken to insure that they are reinforced or rewarded so that there will be a high probability of their recurrence. It is quite likely that students with minimal help might acquire some or all of the desired new responses. It appears more certain, however, that systematic and methodical efforts designed to assure a high probability of correct student responding will result in a more efficient course of learning.

Much of the efficiency of television instruction can depend on the instructor's meeting his responsibility for preparing students to respond appropriately, for

providing the appropriate contexts for these responses, and for reinforcing or rewarding them when they occur. The research reported here has demonstrated several techniques by which students can be prepared to respond appropriately. These techniques can be improved through further research. Whatever role television will play in the educational system of the future, either carrying the burden for teaching some subject matter, or being an adjunct to other forms of instruction, its effective use will result from systematic attention to its methods for stimulating appropriate responses and for altering or revising instructional programs until students do, in fact, attain the capability of making these responses.

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